

Human Peroxisome Proliferator Activated Receptor γField of the Invention

This invention relates to screening for agents active on peroxisome proliferator activated receptor (PPAR). This invention also relates to the cloning and 5 uses of a human peroxisome proliferator activated receptor subtype.

Background of the Invention

Peroxisomes are subcellular organelles found in animals and plants. Peroxisomes contain enzymes for 10 cholesterol and lipid metabolism and respiration.

A variety of chemical agents called peroxisome proliferators induce the proliferation of peroxisomes and increase the capacity of peroxisomes to metabolize fatty acids via increased expression of the enzymes 15 required for the  $\beta$ -oxidation cycle. Peroxisome proliferators include unsaturated fatty acids, hypolipidemic drugs (Reddy, J. K., and Azarnoff, D. L., Nature 283:397-398, 1980), herbicides, leukotriene antagonists, and plasticizers (for a review, see Green, 20 S., Biochem. Pharmacol. 43:393-400, 1992). Hypolipidemic drugs such as clofibrate have been found to lower triglycerides and cholesterol levels in plasma and to be beneficial in the prevention of ischemic heart disease in individuals with elevated levels of 25 cholesterol (Havel, R.J. and Kane, J.P., Ann. Rev. Pharmacol. 13:287-308, 1973). However, fibrate hypolipidemic drugs are also rodent hepatocarcinogens (Reddy, J. K., et al., Br. J. Cancer 40:476-482, 1979; Reddy, J. K., et al., Nature 283:397-398, 1980).

30 There are two hypotheses for peroxisome proliferation. The "lipid overload hypothesis" suggests that an increase in the intracellular concentration of fatty acids is the main stimulus for peroxisome

proliferation (Nestel, P. J., Ann. Rev. Nutr. 10:149-167, 1990, and Phillipson, B. E., et al., N. Engld. J. Med. 312:1210-1216, 1985).

Another hypothesis postulates a receptor  
5 mediated mechanism. Peroxisome proliferator activated  
receptors (PPARs) have been isolated and cloned from  
various species (Isseman, I., and Green, S., Nature  
347:645-650, 1990; Dreyer, C., et al., Cell 68:879-887,  
1992; Gottlicher, M., et al., Proc. Natl. Acad. Sci.  
10 USA 89:4653-4657, 1992; Sher, T., et al., Biochemistry  
32:5598-5604, 1993; and Schmidt, A., et al., Mol.  
Endocrinol. 6:1634-16414-8, 1992). The ligand for PPARs  
is still unidentified.

PPARs belong to the nuclear hormone receptor  
15 superfamily. Some members of the superfamily are  
receptors for the classical steroid hormones; and others  
bind thyroid hormones, vitamin D<sub>3</sub> and retinoic acid.  
However, the putative ligands for many remain to be  
identified, and such receptors have been termed orphan  
20 receptors. Nuclear hormone receptors are intracellular  
proteins that are ligand-dependent transcription  
modulators. They usually have a ligand binding domain  
that binds the cognate ligand with high affinity and  
specificity. They usually also have a DNA binding  
25 domain that recognizes short DNA motifs generally termed  
Hormone Response Elements (HREs).

Issemann and Green, Nature 347:645-650, 1990,  
cloned a mouse peroxisome proliferator activated  
receptor (mPPAR $\alpha$ ) gene from a mouse liver complementary  
30 DNA (cDNA) library. Chimeric receptors constructed  
using the DNA binding domain of either the estrogen or  
glucocorticoid receptor and the putative ligand binding  
domain of mPPAR are able to activate, respectively, an  
estrogen- or glucocorticoid-responsive gene in the  
35 presence of peroxisome proliferators. mPPAR $\alpha$  protein  
binds to a specific peroxisome proliferator response

element (PPRE) located 570 bp upstream of the rat acyl-CoA oxidase gene, which is a key marker of peroxisome proliferator action (Tugwood, J.D., et al. EMBO J. 11:433-439, 1992).

5           Göttlicher et al., Proc. Natl. Acad. Sci. USA 89:4653-4657, 1992, cloned a rat peroxisome proliferator activated receptor (rPPAR) gene from a rat liver cDNA library. PPARs from mouse and rat share 97% homology in amino acid sequence and a particularly well-conserved 10 putative ligand-binding domain. Three members of the Xenopus nuclear hormone receptor superfamily (i.e., XPPAR $\alpha$ , XPPAR $\beta$  and XPPAR $\gamma$ ) have also been found to be structurally and functionally related to the mPPAR $\alpha$  (Dreyer et al., Cell 68:879-887, 1992). Schmidt et al., 15 Molecular Endocrinology 6:1634-1641, 1992, cloned a steroid hormone receptor gene, hNUC1 (also known as hPPAR $\beta$ ), from a human osteosarcoma cell cDNA library. The homology between amino acid sequence of hNUC1 and that of mPPAR $\alpha$  is 62%.

20           Chen et al., Biochem. Biophys. Res. Com. 196:671-677, 1993, cloned two mouse PPAR genes, mNUC1 and mPPAR $\gamma$ , from a neonatal mouse brain cDNA library and an adult mouse heart cDNA library, respectively.

25           Zhu et al., J. Biological Chemistry 268:26817-26820, 1993, cloned a mPPAR $\gamma$  gene from mouse liver cDNA library encoding a 475-amino acid protein with 75% amino acid similarity to XPPAR $\gamma$ , and 55% identity with mPPAR $\alpha$ .

30           Tontonoz et al., Genes & Development 8:1224-34, 1994, cloned a mPPAR $\gamma$ 2 gene from a mouse adipocyte cDNA library. mPPAR $\gamma$ 2 protein is an adipocyte-specific transcription factor.

35           Kliewer et al., Proc. Natl. Acad. Sci. USA 91:7355-59, cloned mPPAR $\gamma$  and mPPAR $\delta$  genes from a mouse liver cDNA library.

              Two subtypes of PPAR receptors,  $\alpha$  and  $\beta$ , have been characterized from humans (see, Sher et al.,

Biochemistry 32:5598-5604, 1993, and Schmidt et al.,  
Molecular Endocrinology 6:1634-1641, 1992).

Summary of the Invention

In related U.S. Application Serial No.

5 08/270,635, entitled "Screening for NUC Inhibitors," filed July 1, 1994, by Mukherjee, and U.S. Application Serial No. 08/143,215, entitled "Human Peroxisome Proliferator Activated Receptor," filed October 25, 1993, by Mukherjee, which is a continuation-in-part of  
10 Application Serial No. 08/141,500, entitled "Human Peroxisome Proliferator Activated Receptor," filed October 22, 1993, by Mukherjee, applicant has isolated two human PPAR subtypes, i.e., PPAR $\alpha$  and hNUC1B. However, the lack of a human PPAR $\gamma$  cDNA clone has  
15 hampered research such as an examination of the expression patterns of the PPAR family of receptors in human tissues and cell lines. To alleviate this problem we cloned and characterized a human PPAR $\gamma$  subtype cDNA.

The present invention relates to hPPAR $\gamma$  poly-  
20 peptides, nucleic acids encoding such polypeptides, cells, tissues and animals containing such polypeptides and nucleic acids, antibodies to such polypeptides, assays utilizing such polypeptides and nucleic acids, and methods relating to all of the foregoing. The  
25 hPPAR $\gamma$  polypeptides, nucleic acids, and antibodies are useful for establishing the tissue specific expression pattern of hPPAR $\gamma$  gene. For example, a Northern blot can be used to reveal tissue specific expression of the gene. They are also useful for screening compounds that  
30 bind to hPPAR $\gamma$  peptides for improved pharmacological profiles for the treatment of diseases with higher potency, efficacy, and fewer side effects.

The present invention is based upon the identification and isolation of a novel human peroxisome  
35 proliferator activated receptor subtype termed hPPAR $\gamma$ .

Thus, in a first aspect the invention features an isolated, purified, enriched or recombinant nucleic acid encoding a hPPAR $\gamma$  polypeptide.

By "isolated" in reference to nucleic acid is meant a polymer of 2 (preferably 21, more preferably 39, most preferably 75) or more nucleotides conjugated to each other, including DNA or RNA that is isolated from a natural source or that is synthesized. The isolated nucleic acid of the present invention is unique in the sense that it is not found in a pure or separated state in nature. Use of the term "isolated" indicates that a naturally occurring sequence has been removed from its normal cellular environment. Thus, the sequence may be in a cell-free solution or placed in a different cellular environment. The term does not imply that the sequence is the only nucleotide chain present, but does indicate that it is the predominate sequence present (at least 10 - 20% more than any other nucleotide sequence) and is essentially free (about 90 - 95% pure at least) of non-nucleotide material naturally associated with it. Therefore, the term does not encompass an isolated chromosome encoding a hPPAR $\gamma$  polypeptide.

By "enriched" in reference to nucleic acid is meant that the specific DNA or RNA sequence constitutes a significantly higher fraction (2 - 5 fold) of the total DNA or RNA present in the cells or solution of interest than in normal or diseased cells or in the cells from which the sequence was taken. This could be caused by a person by preferential reduction in the amount of other DNA or RNA present, or by a preferential increase in the amount of the specific DNA or RNA sequence, or by a combination of the two. However, it should be noted that enriched does not imply that there are no other DNA or RNA sequences present, just that the relative amount of the sequence of interest has been significantly increased in a useful manner and

preferably separate from a sequence library. The term "significantly" here is used to indicate that the level of increase is useful to the person making such an increase, and generally means an increase relative to 5 other nucleic acids of about at least 2 fold, more preferably at least 5 to 10 fold or even more. The term also does not imply that there is no DNA or RNA from other sources. The DNA from other sources may, for example, comprise DNA from a yeast or bacterial genome, 10 or a cloning vector such as pUC19. This term distinguishes from naturally occurring events, such as viral infection, or tumor type growths, in which the level of one mRNA may be naturally increased relative to other species of mRNA. That is, the term is meant to 15 cover only those situations in which a person has intervened to elevate the proportion of the desired nucleic acid.

By "purified" in reference to nucleic acid does not require absolute purity (such as a homogeneous 20 preparation); instead, it represents an indication that the sequence is relatively purer than in the natural environment (compared to the natural level this level should be at least 2-5 fold greater, e.g., in terms of mg/ml). Individual clones isolated from a cDNA library 25 may be purified to electrophoretic homogeneity. The claimed DNA molecules obtained from these clones could be obtained directly from total DNA or from total RNA. The cDNA clones are not naturally occurring, but rather are preferably obtained via manipulation of a partially 30 purified naturally occurring substance (messenger RNA). The construction of a cDNA library from mRNA involves the creation of a synthetic substance (cDNA) and pure individual cDNA clones can be isolated from the synthetic library by clonal selection of the cells 35 carrying the cDNA library. Thus, the process which includes the construction of a cDNA library from mRNA

and isolation of distinct cDNA clones yields an approximately  $10^6$ -fold purification of the native message. Thus, purification of at least one order of magnitude, preferably two or three orders, and more 5 preferably four or five orders of magnitude is expressly contemplated.

By "a hPPAR $\gamma$  polypeptide" is meant two or more contiguous amino acids set forth in the full length amino acid sequence of SEQ ID NO:2, wherein said 10 contiguous amino acids have a sequence different from those of mouse PPAR $\gamma$  polypeptides. The hPPAR $\gamma$  polypeptide can be encoded by a full-length nucleic acid sequence or any portion of the full-length nucleic acid sequence, so long as a functional activity of the 15 polypeptide is retained.

In preferred embodiments the isolated nucleic acid comprises, consists essentially of, or consists of a nucleic acid sequence set forth in the full length nucleic acid sequence SEQ ID NO:1 or at least 27, 30, 20 35, 40 or 50 contiguous nucleotides thereof and the hPPAR $\gamma$  polypeptide comprises, consists essentially of, or consists of at least 9, 10, 15, 20, or 30 contiguous amino acids of a hPPAR $\gamma$  polypeptide.

By "comprising" is meant including, but not 25 limited to, whatever follows the word "comprising". Thus, use of the term "comprising" indicates that the listed elements are required or mandatory, but that other elements are optional and may or may not be present. By "consisting of" is meant including, and 30 limited to, whatever follows the phrase "consisting of". Thus, the phrase "consisting of" indicates that the listed elements are required or mandatory, and that no other elements may be present. By "consisting essentially of" is meant including any elements listed after 35 the phrase, and limited to other elements that do not interfere with or contribute to the activity or action

specified in the disclosure for the listed elements. Thus, the phrase "consisting essentially of" indicates that the listed elements are required or mandatory, but that other elements are optional and may or may not be 5 present depending upon whether or not they affect the activity or action of the listed elements.

Compositions and probes of the present invention may contain human nucleic acid encoding a hPPAR $\gamma$  polypeptide but are substantially free of nucleic acid not encoding a human hPPAR $\gamma$  polypeptide. The human nucleic acid encoding a hPPAR $\gamma$  polypeptide is at least 10 18 contiguous bases of the nucleotide sequence set forth in SEQ. ID NO. 1 and will selectively hybridize to human genomic DNA encoding a hPPAR $\gamma$  polypeptide, or is 15 complementary to such a sequence. The nucleic acid may be isolated from a natural source by cDNA cloning or subtractive hybridization; the natural source may be blood, semen, and tissue of humans; and the nucleic acid may be synthesized by the triester method or by using an 20 automated DNA synthesizer. In yet other preferred embodiments the nucleic acid is a unique region, for example those useful for the design of hybridization probes to facilitate identification and cloning of additional polypeptides, the design of PCR probes to 25 facilitate cloning of additional polypeptides, and obtaining antibodies to polypeptide regions.

By "unique nucleic acid region" is meant a sequence present in a full length nucleic acid coding for a hPPAR $\gamma$  polypeptide that is not present in a 30 sequence coding for any other naturally occurring polypeptide. Such regions preferably comprise 12 or 20 contiguous nucleotides present in the full length nucleic acid encoding a hPPAR $\gamma$  polypeptide.

The invention also features a nucleic acid 35 probe for the detection of a hPPAR $\gamma$  polypeptide or nucleic acid encoding a hPPAR $\gamma$  polypeptide in a sample.

The nucleic acid probe contains nucleic acid that will hybridize to a sequence set forth in SEQ ID NO:1, but not to a mouse PPAR $\gamma$  nucleic acid sequence under high stringency hybridization conditions. In preferred 5 embodiments the nucleic acid probe hybridizes to nucleic acid encoding at least 12, 27, 30, 35, 40 or 50 contiguous amino acids of the full-length sequence set forth in SEQ ID NO:2.

By "high stringency hybridization conditions" 10 is meant those hybridizing conditions that (1) employ low ionic strength and high temperature for washing, for example, 0.015 M NaCl/0.0015 M sodium citrate/0.1% SDS at 50°C; (2) employ during hybridization a denaturing agent such as formamide, for example, 50% (vol/vol) 15 formamide with 0.1% bovine serum albumin/0.1% Ficoll/0.1% polyvinylpyrrolidone/50 mM sodium phosphate buffer at pH 6.5 with 750 mM NaCl, 75 mM sodium citrate at 42°C; or (3) employ 50% formamide, 5 x SSC (0.75 M NaCl, 0.075 M Sodium pyrophosphate, 5 x Denhardt's 20 solution, sonicated salmon sperm DNA (50 g/ml), 0.1% SDS, and 10% dextran sulfate at 42°C, with washes at 25 42°C in 0.2 x SSC and 0.1% SDS. Under stringent hybridization conditions only highly complementary nucleic acid sequences hybridize. Preferably, such conditions prevent hybridization of nucleic acids having 1 or 2 mismatches out of 20 contiguous nucleotides.

Methods for using the probes include detecting 30 the presence or amount hPPAR $\gamma$  RNA in a sample by contacting the sample with a nucleic acid probe under conditions such that hybridization occurs and detecting 35 the presence or amount of the probe bound to hPPAR $\gamma$  RNA. The nucleic acid duplex formed between the probe and a nucleic acid sequence coding for a hPPAR $\gamma$  polypeptide may be used in the identification of the sequence of the nucleic acid detected (for example see, Nelson et al., 35 in Nonisotopic DNA Probe Techniques, p. 275 Academic

Press, San Diego (Kricka, ed., 1992) hereby incorporated by reference herein in its entirety, including any drawings). Kits for performing such methods may be constructed to include a container means having disposed 5 therein a nucleic acid probe.

The invention features recombinant nucleic acid comprising a contiguous nucleic acid sequence encoding a hPPAR $\gamma$  polypeptide, preferably in a cell or an organism. The recombinant nucleic acid may contain a 10 sequence set forth in SEQ ID NO:1 and a vector or a promoter effective to initiate transcription in a host cell. The recombinant nucleic acid can alternatively contain a transcriptional initiation region functional in a cell, a sequence complementary to an RNA sequence 15 encoding a hPPAR $\gamma$  polypeptide and a transcriptional termination region functional in a cell.

In another aspect the invention features an isolated, enriched, purified or recombinant hPPAR $\gamma$  polypeptide.

20 By "isolated" in reference to a polypeptide is meant a polymer of 2 (preferably 7, more preferably 13, most preferably 25) or more amino acids conjugated to each other, including polypeptides that are isolated from a natural source or that are synthesized. The 25 isolated polypeptides of the present invention are unique in the sense that they are not found in a pure or separated state in nature. Use of the term "isolated" indicates that a naturally occurring sequence has been removed from its normal cellular environment. Thus, the 30 sequence may be in a cell-free solution or placed in a different cellular environment. The term does not imply that the sequence is the only amino acid chain present, but that it is the predominate sequence present (at least 10 - 20% more than any other sequence) and is 35 essentially free (about 90 - 95% pure at least) of non-amino acid material naturally associated with it.

By "enriched" in reference to a polypeptide is meant that the specific amino acid sequence constitutes a significantly higher fraction (2 - 5 fold) of the total of amino acids present in the cells or solution of interest than in normal or diseased cells or in the cells from which the sequence was taken. This could be caused by a person by preferential reduction in the amount of other amino acids present, or by a preferential increase in the amount of the specific amino acid sequence of interest, or by a combination of the two. However, it should be noted that enriched does not imply that there are no other amino acid sequences present, just that the relative amount of the sequence of interest has been significantly increased. The term "significantly" here is used to indicate that the level of increase is useful to the person making such an increase, and generally means an increase relative to other amino acids of about at least 2 fold, more preferably at least 5 to 10 fold or even more. The term also does not imply that there is no amino acid from other sources. The amino acid from other sources may, for example, comprise amino acid encoded by a yeast or bacterial genome, or a cloning vector such as pUC19. The term is meant to cover only those situations in which man has intervened to elevate the proportion of the desired amino acid.

By "purified" in reference to a polypeptide does not require absolute purity (such as a homogeneous preparation); instead, it represents an indication that the sequence is relatively purer than in the natural environment (compared to the natural level this level should be at least 2-5 fold greater, e.g., in terms of mg/ml). Purification of at least one order of magnitude, preferably two or three orders, and more preferably four or five orders of magnitude is expressly contemplated. The substance is preferably free of

contamination at a functionally significant level, for example 90%, 95%, or 99% pure.

By "recombinant hPPAR $\gamma$  polypeptide" is meant a hPPAR $\gamma$  polypeptide produced by recombinant DNA techniques such that it is distinct from a naturally occurring polypeptide either in its location (e.g., present in a different cell or tissue than found in nature), purity or structure. Generally, such a recombinant polypeptide will be present in a cell in an amount different from that normally observed in nature. This invention features recombinant hPPAR $\gamma$  polypeptides obtainable using techniques known to those skilled in the art, including those described in McDonnell et al., U.S. Patent Application No. 08/223,943 filed April 6, 1994, Evans et al., U.S. Patent 5,071,773, and PCT application, PCT/US91/00399 filed January 22, 1991 (International Publication No. WO 91/12258), incorporated by reference herein.

In a preferred embodiment, either vector pBacPAK8 (Clontech) or vector pBacPAK9 (Clontech) is used to express recombinant hPPAR $\gamma$  polypeptide in insect cells. In another preferred embodiment, vector pYES2 (Invitrogen) is used to express recombinant hPPAR $\gamma$  polypeptide in yeast cells. In yet another preferred embodiment, pBKCMV (Stratagene) is used to express recombinant hPPAR $\gamma$  polypeptide in mammalian cells.

In preferred embodiments the hPPAR $\gamma$  polypeptide contains at least 9, 10, 15, 20, or 30 contiguous amino acids of the full-length sequence set forth in SEQ ID NO:2.

In yet another aspect the invention features a purified antibody (e.g., a monoclonal or polyclonal antibody) having specific binding affinity to a hPPAR $\gamma$  polypeptide. The antibody contains a sequence of amino acids that is able to specifically bind to a hPPAR $\gamma$  polypeptide. An anti-peptide antibody may be prepared

with techniques known to those skilled in the art, including, but not limited to, those disclosed in Niman, PCT application PCT/US88/03921 (International Publication No. WO 89/04489), incorporated by reference 5 herein.

By "specific binding affinity" is meant that the antibody will bind to a hPPAR $\gamma$  polypeptide at a certain detectable amount but will not bind other polypeptides to the same extent under identical 10 conditions.

Antibodies having specific binding affinity to a hPPAR $\gamma$  polypeptide may be used in methods for detecting the presence and/or amount of a hPPAR $\gamma$  polypeptide in a sample by contacting the sample with 15 the antibody under conditions such that an immunocomplex forms and detecting the presence and/or amount of the antibody conjugated to the hPPAR $\gamma$  polypeptide.

Diagnostic kits for performing such methods may be constructed to include a first container means 20 containing the antibody and a second container means having a conjugate of a binding partner of the antibody and a label.

In another aspect the invention features a hybridoma which produces an antibody having specific 25 binding affinity to a hPPAR $\gamma$  polypeptide.

By "hybridoma" is meant an immortalized cell line which is capable of secreting an antibody, for example a hPPAR $\gamma$  antibody.

In preferred embodiments the hPPAR $\gamma$  antibody 30 comprises a sequence of amino acids that is able to specifically bind a hPPAR $\gamma$  polypeptide.

In other aspects, the invention provides transgenic, nonhuman mammals containing a transgene 35 encoding a hPPAR $\gamma$  polypeptide or a gene effecting the expression of a hPPAR $\gamma$  polypeptide. Such transgenic nonhuman mammals are particularly useful as an *in vivo*

test system for studying the effects of introducing a hPPAR $\gamma$  polypeptide, regulating the expression of a hPPAR $\gamma$  polypeptide (i.e., through the introduction of additional genes, antisense nucleic acids, or 5 ribozymes).

A "transgenic animal" is an animal having cells that contain DNA which has been artificially inserted into a cell, which DNA becomes part of the genome of the animal which develops from that cell.

10 Preferred transgenic animals are primates, mice, rats, cows, pigs, horses, goats, sheep, dogs and cats. The transgenic DNA may encode for a hPPAR $\gamma$  polypeptide. Native expression in an animal may be reduced by providing an amount of anti-sense RNA or DNA effective 15 to reduce expression of the receptor.

In another aspect, the invention describes a recombinant cell or tissue containing a purified nucleic acid coding for a hPPAR $\gamma$  polypeptide. In such cells, the nucleic acid may be under the control of its genomic 20 regulatory elements, or may be under the control of exogenous regulatory elements including an exogenous promoter. By "exogenous" it is meant a promoter that is not normally coupled *in vivo* transcriptionally to the coding sequence for the hPPAR $\gamma$  polypeptide.

25 Another aspect of the invention features a method of detecting the presence or amount of a compound capable of binding to a hPPAR $\gamma$  polypeptide, including endogenous ligands that specifically activate hPPAR $\gamma$ . The method involves incubating the compound with a 30 hPPAR $\gamma$  polypeptide and detecting the presence or amount of the compound bound to the hPPAR $\gamma$  polypeptide. The method makes it possible to screen large collections of natural, semisynthetic, or synthetic compounds for therapeutic agents having specific binding affinity to 35 hPPAR $\gamma$ .

In a preferred embodiment, a cell or an *in vitro* system is transformed with a vector expressing hPPAR $\gamma$  polypeptide and a reporter gene which becomes activated when a ligand binds to hPPAR $\gamma$  polypeptide.

5 Then said cell or *in vitro* system is brought into contact with a test compound. An increase in the activity of the reporter gene would indicate that the test compound is capable of binding hPPAR $\gamma$  polypeptide.

Co-transfection assays will also determine 10 what genes are regulated by hPPAR $\gamma$  and gel retardation assays will indicate the sequence specificity of the binding of hPPAR $\gamma$  to DNA. These data in addition to compounds that selectively activate hPPAR $\gamma$  will indicate the differences between hPPAR $\gamma$  and the other human PPAR 15 subtypes.

Co-transfection assays may be performed as previously described (Heyman, et al. Cell 68:397-406, 1992); Allegretto, et al. J. Biol. Chem. 268:26625-26633 (1993); Isseman, I., and Green, S., 20 Nature 347:645-650, 1990). In an example, the DNA-binding domain of hPPAR $\gamma$  is replaced with the DNA-binding domain of a well characterized nuclear receptor, including, but not limited to, the glucocorticoid or estrogen receptor, to create a chimeric receptor able to 25 activate a glucocorticoid- or estrogen-responsive reporter gene in the presence of the hPPAR $\gamma$ -specific ligand (Giguere, V. and Evans, RM 1990, "Identification of receptors for retinoids as members of the steroid and thyroid hormone receptor family", In : Packer L (ed) 30 Retinoids. Part A: Molecular and Metabolic Aspects. Methods in Enzymology. Academic Press, San Diego, CA, 189:223-232, incorporated by reference herein). The cell is transformed with the chimeric receptor. The cell is also transformed with a reporter vector which 35 comprises a segment encoding a reporter polypeptide under the control of a promoter and a segment of hormone

response element (such as a glucocorticoid- or estrogen-responsive element). When a suitable hormone or ligand is provided to the cell, a hormone receptor - hormone complex is formed and delivered to an appropriate DNA-  
5 binding region to thereby activate the hormone response element and cause expression of the reporter gene. Activation of the reporter gene is detected by standard procedures used for detecting the product of the reporter gene. After introduction of the chimeric  
10 receptor and report gene constructs in recipient cells by transient transection, the cells are challenged with a battery of ligands until a positive response is observed.

The present invention also features novel or  
15 unique compounds capable of binding hPPAR $\gamma$  polypeptide that are identified by methods described above, i.e., compounds that are not known per se or compounds that are not already known for use related to treatment of a pathological condition affected by the level of human  
20 PPAR $\gamma$  protein activity.

Applicant is particularly interested in the identification of agents of low molecular weight (less than 10,000 daltons, preferably less than 5,000, and most preferably less than 1,000) which can be readily  
25 formulated as useful therapeutic agents.

Such agents can then be screened to ensure that they are specific to tissues with pathological conditions induced or aggravated by human PPAR $\gamma$  protein with little or no effect on healthy tissues such that  
30 the agents can be used in a therapeutic or prophylactic manner. If such agents have some effect on healthy tissues they may still be useful in therapeutic treatment, particularly in those diseases which are life threatening.

35 The compounds identified by the method of this invention are particularly useful in the treatment of

diseases and pathological conditions affected by the level of hPPAR $\gamma$  protein, including, without limitation, hyperlipidemia, hypercholesterolemia and hyperlipoproteinemia.

5 The present invention also includes pharmaceutically acceptable compositions prepared for storage and subsequent administration which include a pharmaceutically effective amount of an above-described product in a pharmaceutically acceptable carrier or  
10 diluent.

By "therapeutically effective amount" is meant an amount of a pharmaceutical composition having a therapeutically relevant effect. A therapeutically relevant effect relieves to some extent one or more  
15 symptoms of the disease or condition in the patient; or returns to normal either partially or completely one or more physiological or biochemical parameters associated with or causative of the disease or condition.

Because PPAR $\gamma$  has been implicated in adipose cell function and development (Tontonoz et al., Genes & Development 8:1224-34, 1994, describes that mPPAR $\gamma$  is highly expressed in white adipose tissue and is dramatically induced during differentiation of preadipocytes into adipocytes), human PPAR $\gamma$  agonists and antagonists may be useful for treating obesity and other related disorders.

Other features and advantages of the invention will be apparent from the following description of the preferred embodiments thereof, and from the claims.

30 Description of the Preferred Embodiments

The present invention relates to hPPAR $\gamma$  polypeptides, nucleic acids encoding such polypeptides, cells, tissues and animals containing such nucleic acids, antibodies to such polypeptides, assays utilizing

such polypeptides, and methods relating to all of the foregoing.

I. Nucleic Acid Encoding A hPPAR $\gamma$  Polypeptide.

Included within the scope of this invention 5 are the functional equivalents of the herein-described isolated nucleic acid molecules. The degeneracy of the genetic code permits substitution of certain codons by other codons which specify the same amino acid and hence would give rise to the same protein. The nucleic acid 10 sequence can vary substantially since, with the exception of methionine and tryptophan, the known amino acids can be coded for by more than one codon. Thus, portions or all of the hPPAR $\gamma$  gene could be synthesized to give a nucleic acid sequence significantly different 15 from that shown in SEQ ID NO: 1. The encoded amino acid sequence thereof would, however, be preserved.

In addition, the nucleic acid sequence may comprise a nucleotide sequence which results from the addition, deletion or substitution of at least one 20 nucleotide to the 5'-end and/or the 3'-end of the nucleic acid formula shown in SEQ ID NO: 1 or a derivative thereof. Any nucleotide or polynucleotide may be used in this regard, provided that its addition, deletion or substitution does not alter the amino acid 25 sequence of SEQ ID NO:2 which is encoded by the nucleotide sequence. For example, the present invention is intended to include any nucleic acid sequence resulting from the addition of ATG as an initiation codon at the 5'-end of the inventive nucleic acid 30 sequence or its derivative, or from the addition of TTA, TAG or TGA as a termination codon at the 3'-end of the inventive nucleotide sequence or its derivative. Moreover, the nucleic acid molecule of the present invention may, as necessary, have restriction

endonuclease recognition sites added to its 5'-end and/or 3'-end.

Such functional alterations of a given nucleic acid sequence afford an opportunity to promote secretion 5 and/or processing of heterologous proteins encoded by foreign nucleic acid sequences fused thereto. All variations of the nucleotide sequence of the hPPAR $\gamma$  genes and fragments thereof permitted by the genetic code are, therefore, included in this invention.

10 Further, it is possible to delete codons or to substitute one or more codons by codons other than degenerate codons to produce a structurally modified polypeptide, but one which has substantially the same utility or activity of the polypeptide produced by the 15 unmodified nucleic acid molecule. As recognized in the art, the two polypeptides are functionally equivalent, as are the two nucleic acid molecules which give rise to their production, even though the differences between the nucleic acid molecules are not related to degeneracy 20 of the genetic code.

### II. A Nucleic Acid Probe for the Detection of hPPAR $\gamma$ .

A nucleic acid probe of the present invention may be used to probe an appropriate chromosomal or cDNA library by usual hybridization methods to obtain another 25 nucleic acid molecule of the present invention. A chromosomal DNA or cDNA library may be prepared from appropriate cells according to recognized methods in the art (cf. Molecular Cloning: A Laboratory Manual, second edition, edited by Sambrook, Fritsch, & Maniatis, Cold 30 Spring Harbor Laboratory, 1989).

In the alternative, chemical synthesis is carried out in order to obtain nucleic acid probes having nucleotide sequences which correspond to N-terminal and C-terminal portions of the amino acid 35 sequence of the polypeptide of interest. Thus, the

synthesized nucleic acid probes may be used as primers in a polymerase chain reaction (PCR) carried out in accordance with recognized PCR techniques, essentially according to PCR Protocols, A Guide to Methods and

5 Applications, edited by Michael et al., Academic Press, 1990, utilizing the appropriate chromosomal or cDNA library to obtain the fragment of the present invention.

One skilled in the art can readily design such probes based on the sequence disclosed herein using 10 methods of computer alignment and sequence analysis known in the art (cf. Molecular Cloning: A Laboratory Manual, second edition, edited by Sambrook, Fritsch, & Maniatis, Cold Spring Harbor Laboratory, 1989). The hybridization probes of the present invention can be 15 labeled by standard labeling techniques such as with a radiolabel, enzyme label, fluorescent label, biotin-avidin label, chemiluminescence, and the like. After hybridization, the probes may be visualized using known methods.

20 The nucleic acid probes of the present invention include RNA, as well as DNA probes, such probes being generated using techniques known in the art. The nucleic acid probe may be immobilized on a solid support. Examples of such solid supports include, 25 but are not limited to, plastics such as polycarbonate, complex carbohydrates such as agarose and sepharose, and acrylic resins, such as polyacrylamide and latex beads. Techniques for coupling nucleic acid probes to such solid supports are well known in the art.

30 The test samples suitable for nucleic acid probing methods of the present invention include, for example, cells or nucleic acid extracts of cells, or biological fluids. The sample used in the above-described methods will vary based on the assay format, 35 the detection method and the nature of the tissues, cells or extracts to be assayed. Methods for preparing

nucleic acid extracts of cells are well known in the art and can be readily adapted in order to obtain a sample which is compatible with the method utilized.

III. Probe Based Method And Kit For Detecting  
5 hPPAR $\gamma$ .

One method of detecting the presence of hPPAR $\gamma$  in a sample comprises a) contacting said sample with the above-described nucleic acid probe, under conditions such that hybridization occurs, and b) detecting the 10 presence of said probe bound to said nucleic acid molecule. One skilled in the art would select the nucleic acid probe according to techniques known in the art as described above. Samples to be tested include but should not be limited to RNA samples of human 15 tissue.

A kit for detecting the presence of hPPAR $\gamma$  in a sample comprises at least one container means having disposed therein the above-described nucleic acid probe. The kit may further comprise other containers comprising 20 one or more of the following: wash reagents and reagents capable of detecting the presence of bound nucleic acid probe. Examples of detection reagents include, but are not limited to radiolabelled probes, enzymatic labeled probes (horse radish peroxidase, alkaline phosphatase), 25 and affinity labeled probes (biotin, avidin, or streptavidin).

In detail, a compartmentalized kit includes any kit in which reagents are contained in separate containers. Such containers include small glass 30 containers, plastic containers or strips of plastic or paper. Such containers allow the efficient transfer of reagents from one compartment to another compartment such that the samples and reagents are not cross-contaminated and the agents or solutions of each 35 container can be added in a quantitative fashion from

one compartment to another. Such containers will include a container which will accept the test sample, a container which contains the probe or primers used in the assay, containers which contain wash reagents (such as phosphate buffered saline, Tris-buffers, and the like), and containers which contain the reagents used to detect the hybridized probe, bound antibody, amplified product, or the like. One skilled in the art will readily recognize that the nucleic acid probes described in the present invention can readily be incorporated into one of the established kit formats which are well known in the art.

IV. DNA Constructs Comprising a hPPAR $\gamma$  Nucleic Acid Molecule and Cells Containing These Constructs.

The present invention also relates to a recombinant DNA molecule comprising, 5' to 3', a promoter effective to initiate transcription in a host cell and the above-described nucleic acid molecules. In addition, the present invention relates to a recombinant DNA molecule comprising a vector and an above-described nucleic acid molecules. The present invention also relates to a nucleic acid molecule comprising a transcriptional region functional in a cell, a sequence complimentary to an RNA sequence encoding an amino acid sequence corresponding to the above-described polypeptide, and a transcriptional termination region functional in said cell. The above-described molecules may be isolated and/or purified DNA molecules.

The present invention also relates to a cell or organism that contains an above-described nucleic acid molecule. The peptide may be purified from cells which have been altered to express the peptide. A cell is said to be "altered to express a desired peptide" when the cell, through genetic manipulation, is made to

produce a protein which it normally does not produce or which the cell normally produces at lower levels. One skilled in the art can readily adapt procedures for introducing and expressing either genomic, cDNA, or 5 synthetic sequences into either eukaryotic or prokaryotic cells.

A nucleic acid molecule, such as DNA, is said to be "capable of expressing" a polypeptide if it contains nucleotide sequences which contain 10 transcriptional and translational regulatory information and such sequences are "operably linked" to nucleotide sequences which encode the polypeptide. An operable linkage is a linkage in which the regulatory DNA sequences and the DNA sequence sought to be expressed 15 are connected in such a way as to permit gene sequence expression. The precise nature of the regulatory regions needed for gene sequence expression may vary from organism to organism, but shall in general include a promoter region which, in prokaryotes, contains both 20 the promoter (which directs the initiation of RNA transcription) as well as the DNA sequences which, when transcribed into RNA, will signal synthesis initiation. Such regions will normally include those 5'-non-coding 25 sequences involved with initiation of transcription and translation, such as the TATA box, capping sequence, CAAT sequence, and the like.

If desired, the non-coding region 3' to the sequence encoding an hPPAR- $\gamma$  gene may be obtained by the above-described methods. This region may be retained 30 for its transcriptional termination regulatory sequences, such as termination and polyadenylation. Thus, by retaining the 3'-region naturally contiguous to the DNA sequence encoding an hPPAR $\gamma$  gene, the transcriptional termination signals may be provided. 35 Where the transcriptional termination signals are not satisfactorily functional in the expression host cell,

then a 3' region functional in the host cell may be substituted.

Two DNA sequences (such as a promoter region sequence and a hPPAR $\gamma$  sequence) are said to be operably linked if the nature of the linkage between the two DNA sequences does not (1) result in the introduction of a frame-shift mutation, (2) interfere with the ability of the promoter region sequence to direct the transcription of a hPPAR $\gamma$  gene sequence, or (3) interfere with the ability of a hPPAR $\gamma$  gene sequence to be transcribed by the promoter region sequence. Thus, a promoter region would be operably linked to a DNA sequence if the promoter were capable of effecting transcription of that DNA sequence. Thus, to express a hPPAR $\gamma$  gene, transcriptional and translational signals recognized by an appropriate host are necessary.

The present invention encompasses the expression of the hPPAR $\gamma$  gene (or a functional derivative thereof) in either prokaryotic or eukaryotic cells. Prokaryotic hosts are, generally, very efficient and convenient for the production of recombinant proteins and are, therefore, one type of preferred expression system for the hPPAR $\gamma$  gene. Prokaryotes most frequently are represented by various strains of *E. coli*. However, other microbial strains may also be used, including other bacterial strains.

In prokaryotic systems, plasmid vectors that contain replication sites and control sequences derived from a species compatible with the host may be used. Examples of suitable plasmid vectors may include pBR322, pUC118, pUC119 and the like; suitable phage or bacteriophage vectors may include  $\lambda$ gt10,  $\lambda$ gt11 and the like; and suitable virus vectors may include pMAM-neo, pKRC and the like. Preferably, the selected vector of the present invention has the capacity to replicate in the selected host cell.

Recognized prokaryotic hosts include bacteria such as *E. coil*, *Bacillus*, *Streptomyces*, *Pseudomonas*, *Salmonella*, *Serratia*, and the like. However, under such conditions, the peptide will not be glycosylated. The 5 prokaryotic host must be compatible with the replicon and control sequences in the expression plasmid.

To express hPPAR $\gamma$  (or a functional derivative thereof) in a prokaryotic cell, it is necessary to operably link the hPPAR $\gamma$  sequence to a functional 10 prokaryotic promoter. Such promoters may be either constitutive or, more preferably, regulatable (i.e., inducible or derepressible). Examples of constitutive promoters include the int promoter of bacteriophage  $\lambda$ , the bla promoter of the  $\beta$ -lactamase gene sequence of 15 pBR322, and the CAT promoter of the chloramphenicol acetyl transferase gene sequence of pPR325, and the like. Examples of inducible prokaryotic promoters include the major right and left promoters of bacteriophage  $\lambda$  ( $P_L$  and  $P_R$ ), the trp, recA, lacZ, lacI, 20 and gal promoters of *E. coli*, the  $\alpha$ -amylase (Ulmanen et al., *J. Bacteriol.* 162:176-182(1985)) and the  $\zeta$ -28-specific promoters of *B. subtilis* (Gilman et al., *Gene sequence* 32:11-20(1984)), the promoters of the 25 bacteriophages of *Bacillus* (Gryczan, In: *The Molecular Biology of the Bacilli*, Academic Press, Inc., NY (1982)), and *Streptomyces* promoters (Ward et al., *Mol. Gen. Genet.* 203:468-478(1986)). Prokaryotic promoters are reviewed by Glick (*J. Ind. Microbiol.* 1:277-282(1987)); Cenatiempo (*Biochimie* 68:505-516(1986)); and 30 Gottesman (*Ann. Rev. Genet.* 18:415-442 (1984)).

Proper expression in a prokaryotic cell also requires the presence of a ribosome binding site upstream of the gene sequence-encoding sequence. Such ribosome binding sites are disclosed, for example, by 35 Gold et al. *Ann. Rev. Microbiol.* 35:365-404(1981). The selection of control sequences, expression vectors,

transformation methods, and the like, are dependent on the type of host cell used to express the gene. As used herein, "cell", "cell line", and "cell culture" may be used interchangeably and all such designations include 5 progeny. Thus, the words "transformants" or "transformed cells" include the primary subject cell and cultures derived therefrom, without regard to the number of transfers. It is also understood that all progeny may not be precisely identical in DNA content, due to 10 deliberate or inadvertent mutations. However, as defined, mutant progeny have the same functionality as that of the originally transformed cell.

Host cells which may be used in the expression systems of the present invention are not strictly 15 limited, provided that they are suitable for use in the expression of the hPPAR $\gamma$  polypeptide of interest. Suitable hosts may often include eukaryotic cells. Preferred eukaryotic hosts include, for example, yeast, fungi, insect cells, mammalian cells either in vivo, or 20 in tissue culture. Mammalian cells which may be useful as hosts include HeLa cells, cells of fibroblast origin such as VERO or CHO-K1, or cells of lymphoid origin and their derivatives. Preferred mammalian host cells include SP2/0 and J558L, as well as neuroblastoma cell 25 lines such as IMR 332 which may provide better capacities for correct post-translational processing.

In addition, plant cells are also available as hosts, and control sequences compatible with plant cells are available, such as the cauliflower mosaic virus 35S 30 and 19S, and nopaline synthase promoter and polyadenylation signal sequences. Another preferred host is an insect cell, for example the *Drosophila* larvae. Using insect cells as hosts, the *Drosophila* alcohol dehydrogenase promoter can be used. Rubin, 35 *Science* 240:1453-1459(1988). Alternatively, baculovirus vectors can be engineered to express large amounts of

hPPAR $\gamma$  in insects cells (Jasny, Science 238:1653 (1987); Miller et al., In: Genetic Engineering (1986), Setlow, J.K., et al., eds., Plenum, Vol. 8, pp. 277-297).

Any of a series of yeast gene sequence  
5 expression systems can be utilized which incorporate  
promoter and termination elements from the actively  
expressed gene sequences coding for glycolytic enzymes  
are produced in large quantities when yeast are grown in  
mediums rich in glucose. Known glycolytic gene  
10 sequences can also provide very efficient  
transcriptional control signals. Yeast provides  
substantial advantages in that it can also carry out  
post-translational peptide modifications. A number of  
recombinant DNA strategies exist which utilize strong  
15 promoter sequences and high copy number of plasmids  
which can be utilized for production of the desired  
proteins in yeast. Yeast recognizes leader sequences on  
cloned mammalian gene sequence products and secretes  
peptides bearing leader sequences (i.e., pre-peptides).  
20 For a mammalian host, several possible vector systems  
are available for the expression of hPPAR $\gamma$ .

A wide variety of transcriptional and  
translational regulatory sequences may be employed,  
depending upon the nature of the host. The  
25 transcriptional and translational regulatory signals may  
be derived from viral sources, such as adenovirus,  
bovine papilloma virus, cytomegalovirus, simian virus,  
or the like, where the regulatory signals are associated  
with a particular gene sequence which has a high level  
30 of expression. Alternatively, promoters from mammalian  
expression products, such as actin, collagen, myosin,  
and the like, may be employed. Transcriptional  
initiation regulatory signals may be selected which  
allow for repression or activation, so that expression  
35 of the gene sequences can be modulated. Of interest are  
regulatory signals which are temperature-sensitive so

that by varying the temperature, expression can be repressed or initiated, or are subject to chemical (such as metabolite) regulation.

Expression of hPPAR $\gamma$  in eukaryotic hosts

5 requires the use of eukaryotic regulatory regions. Such regions will, in general, include a promoter region sufficient to direct the initiation of RNA synthesis. Preferred eukaryotic promoters include, for example, the promoter of the mouse metallothionein I gene sequence 10 (Hamer et al., J. Mol. Appl. Gen. 1:273-288(1982)); the TK promoter of Herpes virus (McKnight, Cell 31:355-365 (1982)); the SV40 early promoter (Benoist et al., Nature (London) 290:304-310(1981)); the yeast gal4 gene sequence promoter (Johnston et al., Proc. Natl. Acad. 15 Sci. (USA) 79:6971-6975(1982); Silver et al., Proc. Natl. Acad. Sci. (USA) 81:5951-5955 (1984)).

Translation of eukaryotic mRNA is initiated at the codon which encodes the first methionine. For this reason, it is preferable to ensure that the linkage 20 between a eukaryotic promoter and a DNA sequence which encodes hPPAR $\gamma$  (or a functional derivative thereof) does not contain any intervening codons which are capable of encoding a methionine (i.e., AUG). The presence of such codons results either in a formation of a fusion protein 25 (if the AUG codon is in the same reading frame as the hPPAR $\gamma$  coding sequence) or a frame-shift mutation (if the AUG codon is not in the same reading frame as the hPPAR $\gamma$  coding sequence).

A hPPAR $\gamma$  nucleic acid molecule and an operably 30 linked promoter may be introduced into a recipient prokaryotic or eukaryotic cell either as a nonreplicating DNA (or RNA) molecule, which may either be a linear molecule or, more preferably, a closed covalent circular molecule. Since such molecules are 35 incapable of autonomous replication, the expression of the gene may occur through the transient expression of

the introduced sequence. Alternatively, permanent expression may occur through the integration of the introduced DNA sequence into the host chromosome.

A vector may be employed which is capable of 5 integrating the desired gene sequences into the host cell chromosome. Cells which have stably integrated the introduced DNA into their chromosomes can be selected by also introducing one or more markers which allow for selection of host cells which contain the expression 10 vector. The marker may provide for prototrophy to an auxotrophic host, biocide resistance, e.g., antibiotics, or heavy metals, such as copper, or the like. The selectable marker gene sequence can either be directly linked to the DNA gene sequences to be expressed, or 15 introduced into the same cell by co-transfection.

Additional elements may also be needed for optimal synthesis of single chain binding protein mRNA. These 20 elements may include splice signals, as well as transcription promoters, enhancers, and termination signals. cDNA expression vectors incorporating such elements include those described by Okayama, Molec. Cell. Biol. 3:280 (1983).

The introduced nucleic acid molecule can be incorporated into a plasmid or viral vector capable of 25 autonomous replication in the recipient host. Any of a wide variety of vectors may be employed for this purpose. Factors of importance in selecting a particular plasmid or viral vector include: the ease with which recipient cells that contain the vector may 30 be recognized and selected from those recipient cells which do not contain the vector; the number of copies of the vector which are desired in a particular host; and whether it is desirable to be able to "shuttle" the vector between host cells of different species. 35 Preferred prokaryotic vectors include plasmids such as those capable of replication in *E. coli* (such as, for

example, pBR322, Colel, pSC101, pACYC 184,  $\pi$ VX. Such plasmids are, for example, disclosed by Sambrook (cf. Molecular Cloning: A Laboratory Manual, second edition, edited by Sambrook, Fritsch, & Maniatis, Cold Spring Harbor Laboratory, (1989)). Bacillus plasmids include pC194, pC221, pT127, and the like. Such plasmids are disclosed by Gryczan (In: The Molecular Biology of the Bacilli, Academic Press, NY (1982), pp. 307-329). Suitable Streptomyces plasmids include p1J101 (Kendall et al., J. Bacteriol. 169:4177-4183 (1987)), and streptomyces bacteriophages such as  $\phi$ C31 (Chater et al., In: Sixth International Symposium on Actinomycetales Biology, Akademiai Kaido, Budapest, Hungary (1986), pp. 45-54). Pseudomonas plasmids are reviewed by John et al. (Rev. Infect. Dis. 8:693-704 (1986)), and Izaki (Jpn. J. Bacteriol. 33:729-742 (1978)).

Preferred eukaryotic plasmids include, for example, BPV, vaccinia, SV40, 2-micron circle, and the like, or their derivatives. Such plasmids are well known in the art (Botstein et al., Miami Wntr. Symp. 19:265-274 (1982); Broach, In: The Molecular Biology of the Yeast Saccharomyces: Life Cycle and Inheritance, Cold Spring Harbor Laboratory, Cold Spring Harbor, NY, p. 445-470 (1981); Broach, Cell 28:203-204 (1982); Bollon et al., J. Clin. Hematol. Oncol. 10:39-48 (1980); Maniatis, In: Cell Biology: A Comprehensive Treatise, Vol. 3, Gene Sequence Expression, Academic Press, NY, pp. 563-608 (1980)).

Once the vector or nucleic acid molecule containing the construct(s) has been prepared for expression, the DNA construct(s) may be introduced into an appropriate host cell by any of a variety of suitable means, i.e., transformation, transfection, conjugation, protoplast fusion, electroporation, particle gun technology, calcium phosphate-precipitation, direct microinjection, and the like. After the introduction of

the vector, recipient cells are grown in a selective medium, which selects for the growth of vector-containing cells. Expression of the cloned gene molecule(s) results in the production of hPPAR $\gamma$  or 5 fragments thereof. This can take place in the transformed cells as such, or following the induction of these cells to differentiate (for example, by administration of bromodeoxyuracil to neuroblastoma cells or the like). A variety of incubation conditions 10 can be used to form the peptide of the present invention. The most preferred conditions are those which mimic physiological conditions.

V. Purified hPPAR $\gamma$  Polypeptides.

A variety of methodologies known in the art 15 can be utilized to obtain the peptide of the present invention. The peptide may be purified from tissues or cells which naturally produce the peptide. Alternatively, the above-described isolated nucleic acid fragments could be used to express the hPPAR $\gamma$  protein 20 in any organism. The samples of the present invention include cells, protein extracts or membrane extracts of cells, or biological fluids. The sample will vary based on the assay format, the detection method and the nature of the tissues, cells or extracts used as the sample.

25 Any eukaryotic organism can be used as a source for the peptide of the invention, as long as the source organism naturally contains such a peptide. As used herein, "source organism" refers to the original organism from which the amino acid sequence of the 30 subunit is derived, regardless of the organism the subunit is expressed in and ultimately isolated from.

One skilled in the art can readily follow known methods for isolating proteins in order to obtain the peptide free of natural contaminants. These 35 include, but are not limited to: size-exclusion

chromatography, HPLC, ion-exchange chromatography, and immuno-affinity chromatography.

VI. hPPAR $\gamma$  Antibody And Hybridoma.

The present invention relates to an antibody 5 having binding affinity to a hPPAR $\gamma$  polypeptide. The polypeptide may have the amino acid sequence set forth in SEQ ID NO:2, or mutant or species variation thereof, or at least 9 contiguous amino acids thereof (preferably, at least 10, 15, 20, or 30 contiguous amino 10 acids thereof).

The present invention also relates to an antibody having specific binding affinity to an hPPAR $\gamma$  polypeptide. Such an antibody may be isolated by comparing its binding affinity to a hPPAR $\gamma$  polypeptide 15 with its binding affinity to another polypeptide. Those which bind selectively to hPPAR $\gamma$  would be chosen for use in methods requiring a distinction between hPPAR $\gamma$  and other polypeptides.

The hPPAR $\gamma$  proteins of the present invention 20 can be used in a variety of procedures and methods, such as for the generation of antibodies, for use in identifying pharmaceutical compositions, and for studying DNA/protein interaction.

The hPPAR $\gamma$  peptide of the present invention 25 can be used to produce antibodies or hybridomas. One skilled in the art will recognize that if an antibody is desired, such a peptide would be generated as described herein and used as an immunogen. The antibodies of the present invention include monoclonal and polyclonal 30 antibodies, as well fragments of these antibodies, and humanized forms. Humanized forms of the antibodies of the present invention may be generated using one of the procedures known in the art such as chimerization or CDR grafting. The present invention also relates to a 35 hybridoma which produces the above-described monoclonal

antibody, or binding fragment thereof. A hybridoma is an immortalized cell line which is capable of secreting a specific monoclonal antibody.

In general, techniques for preparing

5 monoclonal antibodies and hybridomas are well known in the art (Campbell, "Monoclonal Antibody Technology: Laboratory Techniques in Biochemistry and Molecular Biology," Elsevier Science Publishers, Amsterdam, The Netherlands (1984); St. Groth et al., *J. Immunol.*  
10 Methods 35:1-21(1980)). Any animal (mouse, rabbit, and the like) which is known to produce antibodies can be immunized with the selected polypeptide. Methods for immunization are well known in the art. Such methods include subcutaneous or intraperitoneal injection of the  
15 polypeptide. One skilled in the art will recognize that the amount of polypeptide used for immunization will vary based on the animal which is immunized, the antigenicity of the polypeptide and the site of injection.

20 The polypeptide may be modified or administered in an adjuvant in order to increase the peptide antigenicity. Methods of increasing the antigenicity of a polypeptide are well known in the art. Such procedures include coupling the antigen with a  
25 heterologous protein (such as globulin or  $\beta$ -galactosidase) or through the inclusion of an adjuvant during immunization.

For monoclonal antibodies, spleen cells from the immunized animals are removed, fused with myeloma  
30 cells, such as SP2/0-Agl4 myeloma cells, and allowed to become monoclonal antibody producing hybridoma cells. Any one of a number of methods well known in the art can be used to identify the hybridoma cell which produces an antibody with the desired characteristics. These  
35 include screening the hybridomas with an ELISA assay, western blot analysis, or radioimmunoassay (Lutz et al.,

Exp. Cell Res. 175:109-124 (1988)). Hybridomas secreting the desired antibodies are cloned and the class and subclass is determined using procedures known in the art (Campbell, Monoclonal Antibody Technology: Laboratory Techniques in Biochemistry and Molecular Biology, *supra* (1984)).

For polyclonal antibodies, antibody containing antisera is isolated from the immunized animal and is screened for the presence of antibodies with the desired specificity using one of the above-described procedures. The above-described antibodies may be detectably labeled. Antibodies can be detectably labeled through the use of radioisotopes, affinity labels (such as biotin, avidin, and the like), enzymatic labels (such as horse radish peroxidase, alkaline phosphatase, and the like) fluorescent labels (such as FITC or rhodamine, and the like), paramagnetic atoms, and the like. Procedures for accomplishing such labeling are well-known in the art, for example, see (Stemberger et al., *J. Histochem. Cytochem.* 18:315 (1970); Bayer et al., *Meth. Enzym.* 62:308 (1979); Engval et al., *Immunot.* 109:129 (1972); Goding, *J. Immunol. Meth.* 13:215 (1976)). The labeled antibodies of the present invention can be used for *in vitro*, *in vivo*, and *in situ* assays to identify cells or tissues which express a specific peptide.

The above-described antibodies may also be immobilized on a solid support. Examples of such solid supports include plastics such as polycarbonate, complex carbohydrates such as agarose and sepharose, acrylic resins and such as polyacrylamide and latex beads. Techniques for coupling antibodies to such solid supports are well known in the art (Weir et al., "Handbook of Experimental Immunology" 4th Ed., Blackwell Scientific Publications, Oxford, England, Chapter 10 (1986); Jacoby et al., *Meth. Enzym.* 34 Academic Press, N.Y. (1974)). The immobilized antibodies of the present

invention can be used for in vitro, in vivo, and in situ assays as well as in immunochromotography.

Furthermore, one skilled in the art can readily adapt currently available procedures, as well as 5 the techniques, methods and kits disclosed above with regard to antibodies, to generate peptides capable of binding to a specific peptide sequence in order to generate rationally designed antipeptide peptides, for example see Hurby et al., "Application of Synthetic 10 Peptides: Antisense Peptides", In Synthetic Peptides, A User's Guide, W.H. Freeman, NY, pp. 289-307(1992), and Kaspczak et al., Biochemistry 28:9230-8(1989).

Anti-peptide peptides can be generated by replacing the basic amino acid residues found in the 15 hPPAR $\gamma$  peptide sequence with acidic residues, while maintaining hydrophobic and uncharged polar groups. For example, lysine, arginine, and/or histidine residues are replaced with aspartic acid or glutamic acid and glutamic acid residues are replaced by lysine, arginine 20 or histidine.

#### VII. An Antibody Based Method And Kit For Detecting hPPAR $\gamma$ .

The present invention encompasses a method of detecting a hPPAR $\gamma$  polypeptide in a sample, comprising: 25 a) contacting the sample with an above-described antibody, under conditions such that immunocomplexes form, and b) detecting the presence of said antibody bound to the polypeptide. In detail, the methods comprise incubating a test sample with one or more of 30 the antibodies of the present invention and assaying whether the antibody binds to the test sample.

Conditions for incubating an antibody with a test sample vary. Incubation conditions depend on the format employed in the assay, the detection methods 35 employed, and the type and nature of the antibody used

in the assay. One skilled in the art will recognize that any one of the commonly available immunological assay formats (such as radioimmunoassays, enzyme-linked immunosorbent assays, diffusion based Ouchterlony, or 5 rocket immunofluorescent assays) can readily be adapted to employ the antibodies of the present invention. Examples of such assays can be found in Chard, "An Introduction to Radioimmunoassay and Related Techniques" Elsevier Science Publishers, Amsterdam, The Netherlands 10 (1986); Bullock et al., "Techniques in Immunocytochemistry," Academic Press, Orlando, FL Vol. 1 (1982), Vol. 2 (1983), Vol. 3 (1985); Tijssen, "Practice and Theory of Enzyme Immunoassays: Laboratory Techniques in Biochemistry and Molecular Biology," 15 Elsevier Science Publishers, Amsterdam, The Netherlands (1985).

The immunological assay test samples of the present invention include cells, protein or membrane extracts of cells, or biological fluids such as blood, 20 serum, plasma, or urine. The test sample used in the above-described method will vary based on the assay format, nature of the detection method and the tissues, cells or extracts used as the sample to be assayed. Methods for preparing protein extracts or membrane 25 extracts of cells are well known in the art and can be readily be adapted in order to obtain a sample which is capable with the system utilized.

A kit contains all the necessary reagents to carry out the previously described methods of detection. 30 The kit may comprise: i) a first container means containing an above-described antibody, and ii) second container means containing a conjugate comprising a binding partner of the antibody and a label. In another preferred embodiment, the kit further comprises one or 35 more other containers comprising one or more of the

following: wash reagents and reagents capable of detecting the presence of bound antibodies.

Examples of detection reagents include, but are not limited to, labeled secondary antibodies, or in 5 the alternative, if the primary antibody is labeled, the chromophoric, enzymatic, or antibody binding reagents which are capable of reacting with the labeled antibody. The compartmentalized kit may be as described above for nucleic acid probe kits. One skilled in the art will 10 readily recognize that the antibodies described in the present invention can readily be incorporated into one of the established kit formats which are well known in the art.

VIII. Isolation of Compounds Which  
15 Interact With hPPAR $\gamma$ .

The present invention also relates to a method of detecting a compound capable of binding to a hPPAR $\gamma$  polypeptide comprising incubating the compound with hPPAR $\gamma$  and detecting the presence of the compound bound 20 to hPPAR $\gamma$ . The compound may be present within a complex mixture, for example, serum, body fluid, or cell extracts.

The present invention also relates to a method of detecting an agonist or antagonist of hPPAR $\gamma$  activity 25 comprising incubating cells that produce hPPAR $\gamma$  in the presence of a compound and detecting changes in the level of hPPAR $\gamma$  activity. Standard techniques can be used, including, but not limited to, what is described in PCT application PCT/US94/03795 entitled "Method for screening for receptor agonists," by McDonnell et al. 30 (publication no. WO 94/23068) and U.S. application 08/270,635 entitled "Screening for NUC inhibitors," by Mukherjee, incorporated by reference herein. The compounds thus identified would produce a change in 35 activity indicative of the presence of the compound.

The compound may be present within a complex mixture, for example, serum, body fluid, or cell extracts. Once the compound is identified it can be isolated using techniques well known in the art.

5 The present invention also encompasses a method of agonizing (stimulating) or antagonizing hPPAR $\gamma$  associated activity in a mammal comprising administering to said mammal an agonist or antagonist to hPPAR $\gamma$  in an amount sufficient to effect said agonism or antagonism.

10 **IX. Transgenic Animals.**

A variety of methods are available for the production of transgenic animals associated with this invention. DNA can be injected into the pronucleus of a fertilized egg before fusion of the male and female pronuclei, or injected into the nucleus of an embryonic cell (e.g., the nucleus of a two-cell embryo) following the initiation of cell division (Brinster *et al.*, *Proc. Nat. Acad. Sci. USA* 82: 4438-4442 (1985)). Embryos can be infected with viruses, especially retroviruses, 20 modified to carry inorganic-ion receptor nucleotide sequences of the invention.

Pluripotent stem cells derived from the inner cell mass of the embryo and stabilized in culture can be manipulated in culture to incorporate nucleotide 25 sequences of the invention. A transgenic animal can be produced from such cells through implantation into a blastocyst that is implanted into a foster mother and allowed to come to term. Animals suitable for transgenic experiments can be obtained from standard 30 commercial sources such as Charles River (Wilmington, MA), Taconic (Germantown, NY), Harlan Sprague Dawley (Indianapolis, IN), etc.

The procedures for manipulation of the rodent embryo and for microinjection of DNA into the pronucleus 35 of the zygote are well known to those of ordinary skill

in the art (Hogan *et al.*, supra). Microinjection procedures for fish, amphibian eggs and birds are detailed in Houdebine and Chourrout, Experientia 47: 897-905 (1991). Other procedures for introduction of 5 DNA into tissues of animals are described in U.S. Patent No., 4,945,050 (Sandford *et al.*, July 30, 1990).

By way of example only, to prepare a transgenic mouse, female mice are induced to superovulate. Females are placed with males, and the 10 mated females are sacrificed by CO<sub>2</sub> asphyxiation or cervical dislocation and embryos are recovered from excised oviducts. Surrounding cumulus cells are removed. Pronuclear embryos are then washed and stored until the time of injection. Randomly cycling adult 15 female mice are paired with vasectomized males. Recipient females are mated at the same time as donor females. Embryos then are transferred surgically. The procedure for generating transgenic rats is similar to that of mice. See Hammer *et al.*, Cell 63:1099-1112 20 (1990).

Methods for the culturing of embryonic stem (ES) cells and the subsequent production of transgenic animals by the introduction of DNA into ES cells using methods such as electroporation, calcium phosphate/DNA 25 precipitation and direct injection also are well known to those of ordinary skill in the art. See, for example, Teratocarcinomas and Embryonic Stem Cells, A Practical Approach, E.J. Robertson, ed., IRL Press (1987).

30 In cases involving random gene integration, a clone containing the sequence(s) of the invention is co-transfected with a gene encoding resistance. Alternatively, the gene encoding neomycin resistance is physically linked to the sequence(s) of the invention. 35 Transfection and isolation of desired clones are carried

out by any one of several methods well known to those of ordinary skill in the art (E.J. Robertson, supra).

DNA molecules introduced into ES cells can also be integrated into the chromosome through the 5 process of homologous recombination. Capecchi, Science 244: 1288-1292 (1989). Methods for positive selection of the recombination event (i.e., neo resistance) and dual positive-negative selection (i.e., neo resistance and gancyclovir resistance) and the subsequent 10 identification of the desired clones by PCR have been described by Capecchi, supra and Joyner et al., Nature 338: 153-156 (1989), the teachings of which are incorporated herein. The final phase of the procedure is to inject targeted ES cells into blastocysts and to 15 transfer the blastocysts into pseudopregnant females. The resulting chimeric animals are bred and the offspring are analyzed by Southern blotting to identify individuals that carry the transgene. Procedures for the production of non-rodent mammals and other animals 20 have been discussed by others. See Houdebine and Chourrout, supra; Pursel et al., Science 244:1281-1288 (1989); and Simms et al., Bio/Technology 6:179-183 (1988).

#### X. Gene Therapy

25 hPPAR $\gamma$  or its genetic sequences will be useful in gene therapy (reviewed in Miller, Nature 357:455-460, (1992). Miller states that advances have resulted in practical approaches to human gene therapy that have demonstrated positive initial results. An *in vivo* model 30 of gene therapy for human severe combined immunodeficiency is described in Ferrari, et al., Science 251:1363-1366, (1991). The basic science of gene therapy is described in Mulligan, Science 260:926-931, (1993).

In one preferred embodiment, an expression vector containing the hPPAR $\gamma$  coding sequence is inserted into cells, the cells are grown *in vitro* and then infused in large numbers into patients. In another 5 preferred embodiment, a DNA segment containing a promoter of choice (for example a strong promoter) is transferred into cells containing an endogenous hPPAR $\gamma$  in such a manner that the promoter segment enhances expression of the endogenous hPPAR $\gamma$  gene (for example, 10 the promoter segment is transferred to the cell such that it becomes directly linked to the endogenous hPPAR $\gamma$  gene).

The gene therapy may involve the use of an adenovirus containing hPPAR $\gamma$  cDNA targeted to a tumor, 15 systemic hPPAR $\gamma$  increase by implantation of engineered cells, injection with hPPAR $\gamma$  virus, or injection of naked hPPAR $\gamma$  DNA into appropriate tissues.

Target cell populations (*e.g.*, hematopoietic or nerve cells) may be modified by introducing altered 20 forms of hPPAR $\gamma$  in order to modulate the activity of such cells.

Expression vectors derived from viruses such as retroviruses, vaccinia virus, adenovirus, adeno-associated virus, herpes viruses, several RNA viruses, 25 or bovine papilloma virus, may be used for delivery of nucleotide sequences (*e.g.*, cDNA) encoding recombinant hPPAR $\gamma$  protein into the targeted cell population (*e.g.*, tumor cells). Methods which are well known to those skilled in the art can be used to construct recombinant 30 viral vectors containing coding sequences. See, for example, the techniques described in Maniatis et al., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory, N.Y. (1989), and in Ausubel et al., Current Protocols in Molecular Biology, Greene 35 Publishing Associates and Wiley Interscience, N.Y. (1989). Alternatively, recombinant nucleic acid mole-

cules encoding protein sequences can be used as naked DNA or in reconstituted system e.g., liposomes or other lipid systems for delivery to target cells (See e.g., Felgner et al., *Nature* 337:387-8, 1989). Several other 5 methods for the direct transfer of plasmid DNA into cells exist for use in human gene therapy and involve targeting the DNA to receptors on cells by complexing the plasmid DNA to proteins. See, Miller, *supra*.

In its simplest form, gene transfer can be 10 performed by simply injecting minute amounts of DNA into the nucleus of a cell, through a process of microinjection. Capecchi MR, Cell 22:479-88 (1980). Once recombinant genes are introduced into a cell, they 15 can be recognized by the cell's normal mechanisms for transcription and translation, and a gene product will be expressed. Other methods have also been attempted for introducing DNA into larger numbers of cells. These methods include: transfection, wherein DNA is precipitated with CaPO<sub>4</sub> and taken into cells by 20 pinocytosis (Chen C. and Okayama H, Mol. Cell Biol. 7:2745-52 (1987)); electroporation, wherein cells are exposed to large voltage pulses to introduce holes into the membrane (Chu G. et al., Nucleic Acids Res., 15:1311-26 (1987)); lipofection/liposome fusion, wherein 25 DNA is packaged into lipophilic vesicles which fuse with a target cell (Felgner PL., et al., Proc. Natl. Acad. Sci. USA. 84:7413-7 (1987)); and particle bombardment using DNA bound to small projectiles (Yang NS. et al., Proc. Natl. Acad. Sci. 87:9568-72 (1990)). Another 30 method for introducing DNA into cells is to couple the DNA to chemically modified proteins.

It has also been shown that adenovirus 35 proteins are capable of destabilizing endosomes and enhancing the uptake of DNA into cells. The admixture of adenovirus to solutions containing DNA complexes, or the binding of DNA to polylysine covalently attached to

adenovirus using protein crosslinking agents substantially improves the uptake and expression of the recombinant gene. Curiel DT et al., Am. J. Respir. Cell. Mol. Biol., 6:247-52 (1992).

5 As used herein "gene transfer" means the process of introducing a foreign nucleic acid molecule into a cell. Gene transfer is commonly performed to enable the expression of a particular product encoded by the gene. The product may include a protein,  
10 polypeptide, anti-sense DNA or RNA, or enzymatically active RNA. Gene transfer can be performed in cultured cells or by direct administration into animals. Generally gene transfer involves the process of nucleic acid contact with a target cell by non-specific or  
15 receptor mediated interactions, uptake of nucleic acid into the cell through the membrane or by endocytosis, and release of nucleic acid into the cytoplasm from the plasma membrane or endosome. Expression may require, in addition, movement of the nucleic acid into the nucleus  
20 of the cell and binding to appropriate nuclear factors for transcription.

As used herein "gene therapy" is a form of gene transfer and is included within the definition of gene transfer as used herein and specifically refers to  
25 gene transfer to express a therapeutic product from a cell *in vivo* or *in vitro*. Gene transfer can be performed *ex vivo* on cells which are then transplanted into a patient, or can be performed by direct administration of the nucleic acid or nucleic acid-  
30 protein complex into the patient.

In another preferred embodiment, a vector having nucleic acid sequences encoding hPPAR $\gamma$  is provided in which the nucleic acid sequence is expressed only in specific tissue. Methods of achieving tissue-specific gene expression as set forth in International  
35

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In all of the preceding vectors set forth above, a further aspect of the invention is that the 5 nucleic acid sequence contained in the vector may include additions, deletions or modifications to some or all of the sequence of the nucleic acid, as defined above.

In another preferred embodiment, a method of 10 gene replacement is set forth. "Gene replacement" as used herein means supplying a nucleic acid sequence which is capable of being expressed *in vivo* in an animal and thereby providing or augmenting the function of an endogenous gene which is missing or defective in the 15 animal.

#### XI. Pharmaceutical Formulations and Modes of Administration

The particular compound or antibody that affects the disorder of interest can be administered to 20 a patient either by themselves, or in pharmaceutical compositions where it is mixed with suitable carriers or excipient(s). In treating a patient exhibiting a disorder of interest, a therapeutically effective amount of a agent or agents such as these is administered. A 25 therapeutically effective dose refers to that amount of the compound that results in amelioration of symptoms or a prolongation of survival in a patient.

Toxicity and therapeutic efficacy of such compounds can be determined by standard pharmaceutical 30 procedures in cell cultures or experimental animals, e.g., for determining the LD<sub>50</sub> (the dose lethal to 50% of the population) and the ED<sub>50</sub> (the dose therapeutically effective in 50% of the population). The dose ratio between toxic and therapeutic effects is the therapeutic 35 index and it can be expressed as the ratio LD<sub>50</sub>/ED<sub>50</sub>.

Compounds which exhibit large therapeutic indices are preferred. The data obtained from these cell culture assays and animal studies can be used in formulating a range of dosage for use in human. The dosage of such 5 compounds lies preferably within a range of circulating concentrations that include the  $ED_{50}$  with little or no toxicity. The dosage may vary within this range depending upon the dosage form employed and the route of administration utilized.

10 For any compound used in the method of the invention, the therapeutically effective dose can be estimated initially from cell culture assays. For example, a dose can be formulated in animal models to achieve a circulating plasma concentration range that 15 includes the  $IC_{50}$  as determined in cell culture (i.e., the concentration of the test compound which achieves a half-maximal disruption of the protein complex, or a half-maximal inhibition of the cellular level and/or activity of a complex component). Such information can 20 be used to more accurately determine useful doses in humans. Levels in plasma may be measured, for example, by HPLC.

The exact formulation, route of administration and dosage can be chosen by the individual physician in 25 view of the patient's condition. (See e.g. Fingl et al., in The Pharmacological Basis of Therapeutics, 1975, Ch. 1 p. 1). It should be noted that the attending physician would know how to and when to terminate, interrupt, or adjust administration due to 30 toxicity, or to organ dysfunctions. Conversely, the attending physician would also know to adjust treatment to higher levels if the clinical response were not adequate (precluding toxicity). The magnitude of an administrated dose in the management of the oncogenic 35 disorder of interest will vary with the severity of the condition to be treated and to the route of

administration. The severity of the condition may, for example, be evaluated, in part, by standard prognostic evaluation methods. Further, the dose and perhaps dose frequency, will also vary according to the age, body 5 weight, and response of the individual patient. A program comparable to that discussed above may be used in veterinary medicine.

Depending on the specific conditions being treated, such agents may be formulated and administered 10 systemically or locally. Techniques for formulation and administration may be found in Remington's Pharmaceutical Sciences, 18th ed., Mack Publishing Co., Easton, PA (1990). Suitable routes may include oral, rectal, transdermal, vaginal, transmucosal, or intestinal administration; parenteral delivery, including intramuscular, 15 subcutaneous, intramedullary injections, as well as intrathecal, direct intraventricular, intravenous, intraperitoneal, intranasal, or intraocular injections, just to name a few.

20 For injection, the agents of the invention may be formulated in aqueous solutions, preferably in physiologically compatible buffers such as Hanks's solution, Ringer's solution, or physiological saline buffer. For such transmucosal administration, penetrants appropriate 25 to the barrier to be permeated are used in the formulation. Such penetrants are generally known in the art.

Use of pharmaceutically acceptable carriers to formulate the compounds herein disclosed for the practice of the invention into dosages suitable for systemic 30 administration is within the scope of the invention.

With proper choice of carrier and suitable manufacturing practice, the compositions of the present invention, in particular, those formulated as solutions, may be administered parenterally, such as by intravenous injection. 35 The compounds can be formulated readily using pharmaceutically acceptable carriers well known in the art into

dosages suitable for oral administration. Such carriers enable the compounds of the invention to be formulated as tablets, pills, capsules, liquids, gels, syrups, slurries, suspensions and the like, for oral ingestion 5 by a patient to be treated.

Agents intended to be administered intracellularly may be administered using techniques well known to those of ordinary skill in the art. For example, such agents may be encapsulated into liposomes, then administered as described above. Liposomes are spherical lipid 10 bilayers with aqueous interiors. All molecules present in an aqueous solution at the time of liposome formation are incorporated into the aqueous interior. The liposomal contents are both protected from the external 15 microenvironment and, because liposomes fuse with cell membranes, are efficiently delivered into the cell cytoplasm. Additionally, due to their hydrophobicity, small organic molecules may be directly administered intracellularly.

20 Pharmaceutical compositions suitable for use in the present invention include compositions wherein the active ingredients are contained in an effective amount to achieve its intended purpose. Determination of the effective amounts is well within the capability 25 of those skilled in the art, especially in light of the detailed disclosure provided herein. In addition to the active ingredients, these pharmaceutical compositions may contain suitable pharmaceutically acceptable carriers comprising excipients and auxiliaries which 30 facilitate processing of the active compounds into preparations which can be used pharmaceutically. The preparations formulated for oral administration may be in the form of tablets, dragees, capsules, or solutions. The pharmaceutical compositions of the present invention 35 may be manufactured in a manner that is itself known, e.g., by means of conventional mixing, dissolving,

granulating, dragee-making, levitating, emulsifying, encapsulating, entrapping or lyophilizing processes.

Pharmaceutical formulations for parenteral administration include aqueous solutions of the active 5 compounds in water-soluble form. Additionally, suspensions of the active compounds may be prepared as appropriate oily injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acid esters, such as ethyl 10 oleate or triglycerides, or liposomes. Aqueous injection suspensions may contain substances which increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol, or dextran. Optionally, the suspension may also contain suitable stabilizers or 15 agents which increase the solubility of the compounds to allow for the preparation of highly concentrated solutions.

Pharmaceutical preparations for oral use can be obtained by combining the active compounds with solid 20 excipient, optionally grinding a resulting mixture, and processing the mixture of granules, after adding suitable auxiliaries, if desired, to obtain tablets or dragee cores. Suitable excipients are, in particular, fillers such as sugars, including lactose, sucrose, 25 mannitol, or sorbitol; cellulose preparations such as, for example, maize starch, wheat starch, rice starch, potato starch, gelatin, gum tragacanth, methyl cellulose, hydroxypropylmethyl-cellulose, sodium carboxymethylcellulose, and/or polyvinylpyrrolidone (PVP). If 30 desired, disintegrating agents may be added, such as the cross-linked polyvinyl pyrrolidone, agar, or alginic acid or a salt thereof such as sodium alginate.

Dragee cores are provided with suitable coatings. For this purpose, concentrated sugar solutions 35 may be used, which may optionally contain gum arabic, talc, polyvinyl pyrrolidone, carbopol gel, polyethylene

glycol, and/or titanium dioxide, lacquer solutions, and suitable organic solvents or solvent mixtures. Dye-stuffs or pigments may be added to the tablets or dragee coatings for identification or to characterize different 5 combinations of active compound doses.

Pharmaceutical preparations which can be used orally include push-fit capsules made of gelatin, as well as soft, sealed capsules made of gelatin and a plasticizer, such as glycerol or sorbitol. The push-fit 10 capsules can contain the active ingredients in admixture with filler such as lactose, binders such as starches, and/or lubricants such as talc or magnesium stearate and, optionally, stabilizers. In soft capsules, the active compounds may be dissolved or suspended in suitable liquids, such as fatty oils, liquid paraffin, or 15 liquid polyethylene glycols. In addition, stabilizers may be added.

Some methods of delivery that may be used include:

- 20 a. encapsulation in liposomes,
- b. transduction by retroviral vectors,
- c. localization to nuclear compartment utilizing nuclear targeting site found on most nuclear proteins,
- 25 d. transfection of cells *ex vivo* with subsequent reimplantation or administration of the transfected cells,
- e. a DNA transporter system.

A hPPAR $\gamma$  nucleic acid sequence may be 30 administered utilizing an *ex vivo* approach whereby cells are removed from an animal, transduced with the hPPAR $\gamma$  nucleic acid sequence and reimplanted into the animal. The liver can be accessed by an *ex vivo* approach by removing hepatocytes from an animal, transducing the 35 hepatocytes *in vitro* with the hPPAR $\gamma$  nucleic acid sequence and reimplanting them into the animal (e.g., as

described for rabbits by Chowdhury et al, Science 254: 1802-1805, 1991, or in humans by Wilson, Hum. Gene Ther. 3: 179-222, 1992) incorporated herein by reference.

Many nonviral techniques for the delivery of a hPPAR $\gamma$  nucleic acid sequence into a cell can be used, including direct naked DNA uptake (e.g., Wolff et al., Science 247: 1465-1468, 1990), receptor-mediated DNA uptake, e.g., using DNA coupled to asialoorosomucoid which is taken up by the asialoglycoprotein receptor in the liver (Wu and Wu, J. Biol. Chem. 262: 4429-4432, 1987; Wu et al., J. Biol. Chem. 266: 14338-14342, 1991), and liposome-mediated delivery (e.g., Kaneda et al., Expt. Cell Res. 173: 56-69, 1987; Kaneda et al., Science 243: 375-378, 1989; Zhu et al., Science 261: 209-211, 1993). Many of these physical methods can be combined with one another and with viral techniques; enhancement of receptor-mediated DNA uptake can be effected, for example, by combining its use with adenovirus (Curiel et al., Proc. Natl. Acad. Sci. USA 88: 8850-8854, 1991; Cristiano et al., Proc. Natl. Acad. Sci. USA 90: 2122-2126, 1993).

The hPPAR $\gamma$  or nucleic acid encoding hPPAR $\gamma$  may also be administered via an implanted device that provides a support for growing cells. Thus, the cells may remain in the implanted device and still provide the useful and therapeutic agents of the present invention.

#### EXAMPLES

The examples below are non-limiting and are merely representative of various aspects and features of the procedures used to identify the full-length nucleic acid and amino acid sequences of hPPAR $\gamma$ .

#### cDNA cloning

What follows is an example of the cloning of a hPPAR $\gamma$  from a human heart cDNA library. Those of

ordinary skill in the art will recognize that equivalent procedures can be readily used to isolate hPPAR $\gamma$  from cDNA libraries or genomic libraries of other tissues.

The recipes for buffers, mediums, and  
5 solutions in the following experiments are given in J. Sambrook, E. F. Fritsch, and T. Maniatis, Molecular Cloning: A Laboratory Manual, 2 Ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, 1989.

A human heart cDNA library, Human Heart  
10 5'-STRETCH in  $\lambda$ -gt10, was purchased from Clontech Laboratories Inc., Palo Alto, California.

A fragment isolated from a mPPAR $\gamma$  cDNA clone (Chen et al., Biochem. Biophys. Res. Com. 196:671-677, 1993) by digestion with EcoRI, was labeled with  
15  $[^{32}\text{P}]$ -dCTP by random priming and was utilized to identify potential hPPAR $\gamma$  cDNA clones.

Approximately  $2 \times 10^6$  phage plaques from the human heart cDNA library were screened with the mPPAR $\gamma$  probe at low stringency (35% formamide, 5 x SSC, 0.1%  
20 SDS, 100  $\mu\text{g}/\text{ml}$  fish DNA at 37°C). Positive clones were isolated and subcloned into pBKCMV (Strategene) or pCR $\text{II}$  (Invitrogen) for sequencing. The clone contains an open reading frame of 1482 nucleotides. There is a 89% nucleotide identity (i.e., "homology") between the  
25 hPPAR $\gamma$  clone and the mPPAR $\gamma$  sequence.

hPPAR $\gamma$  may start from any of the three methionines identified in SEQ. ID NO. 2, i.e., Met (1), Met (18) and Met (20). The deduced amino acid sequence of hPPAR $\gamma$  predicts a protein of 494, 477 or 475 amino acids. A comparison of the amino acid sequences between human and mouse show 96% amino acid sequence identity (i.e., "homology").

Expression Pattern of Human PPAR- $\gamma$

Northern blot analysis of mRNAs isolated from various human tissues can be conducted to determine the expression pattern of hPPAR $\gamma$ .

For mammalian expression studies, the entire 5 hPPAR $\gamma$  cDNA is subcloned into the EcoRI site of pcDNA-1 (Invitrogen, San Diego, CA) under the control of the CMV promoter.

A human multiple tissue Northern blot (Clontech Laboratories Inc.) containing 2 $\mu$ g of poly-A 10 plus mRNA isolated from several human tissues is hybridized with the full length hPPAR $\gamma$  cDNA that was random prime labeled with [ $^{32}$ P]-dCTP. The hybridization and all washes are conducted under high-stringency.

All publications referenced are incorporated 15 by reference herein, including the nucleic acid sequences and amino acid sequences listed in each publication.

Other embodiments are within the following claims.